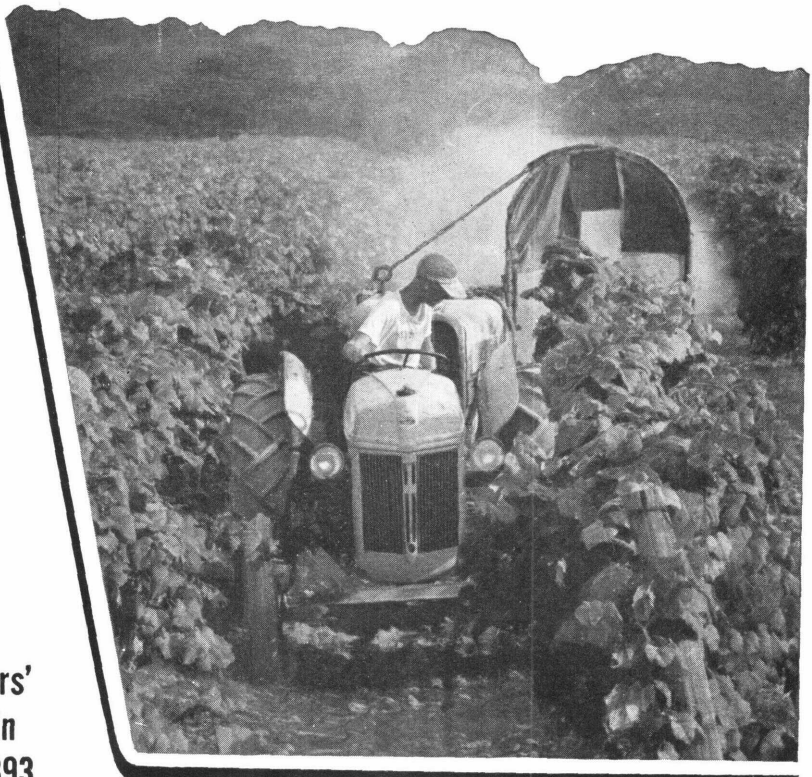
Control of Grape Diseases and Insects in Eastern United States



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DISEASES AND INSECTS, important among which are black rot, downy mildew, anthracnose, grape berry moth, and grape leafhoppers, cause serious damage to grapes in eastern United States. The control of these and other diseases and pests is an important factor in the production program if grapes of high quality are to be harvested. No grower can afford to neglect the necessary control measures.

This bulletin gives information on the best available measures for the control of the most important diseases and insects affecting grapes in the States lying east of the Rocky Mountains. For that region this bulletin supersedes Farmers' Bulletin 1220, Insect and Fungous Enemies of the Grape.

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CONTROL OF GRAPE DISEASES AND INSECTS IN EASTERN UNITED STATES

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INTRODUCTION

DAMAGE DONE TO GRAPES in the United States by diseases and insects varies considerably in different regions and from year to year. Weather conditions during the critical periods for infection may either favor or suppress the development and spread of the organisms causing the diseases. In some districts in the Northern States grape diseases are so easily controlled that in some years one or two applications of bordeaux mixture spray are sufficient for control, whereas in other years the full spray program is hardly adequate. Grape diseases are most prevalent and more difficult to control in the Southeastern States because of prevailing high temperatures, abundant rainfall, and a long growing season.

The grape is subject to attack by a large number of insects of which only a few of the more important are mentioned in this bulletin. The general control program suggested on page 36, however, will in most cases prove adequate for the control of the insects most commonly encountered. For information on problems not dealt with herein, it is suggested that the readers write to their State agricultural experiment stations or to the United States Department of Agriculture, describing the injury in detail and sending specimens.

[1] G. A. Runner, who was the junior author in the original edition, died July 11, 1941.

Living insects should not be sent through the mail; they should be killed and sent dry or preserved in alcohol or formalin.

Conditions in small home vineyards, however, are often so favorable for both insects and parasitic fungi that control is difficult. The few vines usually grown in home gardens are often trained on the side of a building, on an overhead trellis, or in some location where they receive sunshine only a part of the day. Vines so grown cannot be pruned and sprayed properly; if shaded part of the day they will be in an environment favorable for the development and spread of fungus parasites, thus making control difficult, if not impossible.

DISEASES PRINCIPALLY OF AMERICAN BUNCH GRAPES

Varieties and types of grapes grown influence the amount of disease. The vinifera, or European, varieties as a class are very susceptible and cannot be grown successfully east of the Rocky Mountains, except in a few favorable districts. Varieties of the American bunch grape vary widely as to susceptibility to disease. The muscadine group of grapes, of which the Scuppernong is a representative, are highly resistant to the more destructive diseases.

The organisms that cause the most important grape diseases hibernate on the previous year's vines, leaves, and fruits and may become active again very early in the spring. Then new spores are produced that infect the young leaves and vines and later the blossoms and fruits. Winter pruning of the surplus vine growth and cultivation of the soil will dispose of a large amount of the infectious material, but enough may remain to spread the disease thoroughly unless spray is applied early in the spring.

BLACK ROT

Black rot, caused by the fungus *Guignardia bidwellii* (Ell.) Viala & Ravaz, is the most widespread disease of grapes and in the eastern grape-producing regions causes greater loss than all other diseases combined. It is quite generally distributed in most grape-growing areas east of the Rocky Mountains, but it is most prevalent and destructive east of the Mississippi River and is especially destructive in the hotter, humid portion of this area and west along the Gulf coast of Louisiana and Texas. All vinifera, or European, varieties of grapes and many of the American bunch grapes are highly susceptible to attack by the black rot fungus. A few American bunch grape varieties that may be listed as having considerable resistance and good table qualities are Campbell Early, Delaware, Diamond, Dracut Amber, Eaton, Lucile, Lutie, Moore Early, Portland, and Worden.

The fungus causing black rot may attack the leaves, shoots, blossoms, and fruits of the bunch grapes. Only the young and tender tissues are infected. Even the fruit becomes resistant after it has attained about full size. Rotting of the fruits after they begin to color may be caused by other fungi.

Although spotting occurs on the leaves (fig. 1) and vines in early spring, the disease does not attract much attention until midsummer when the nearly half-grown berries begin to rot. The disease on the fruit begins to show as light-brownish, soft circular spots; these increase rapidly in size, and within 2 or 3 days the entire berry is

discolored. Within 24 hours small black specks begin to appear at the surface of the discolored berry. Very soon the decaying berries begin to shrivel, and within a week or 10 days are transformed into hard, black, shriveled mummies. The hard dead berries may remain attached to the bunch for several weeks (fig. 2). Some shattering

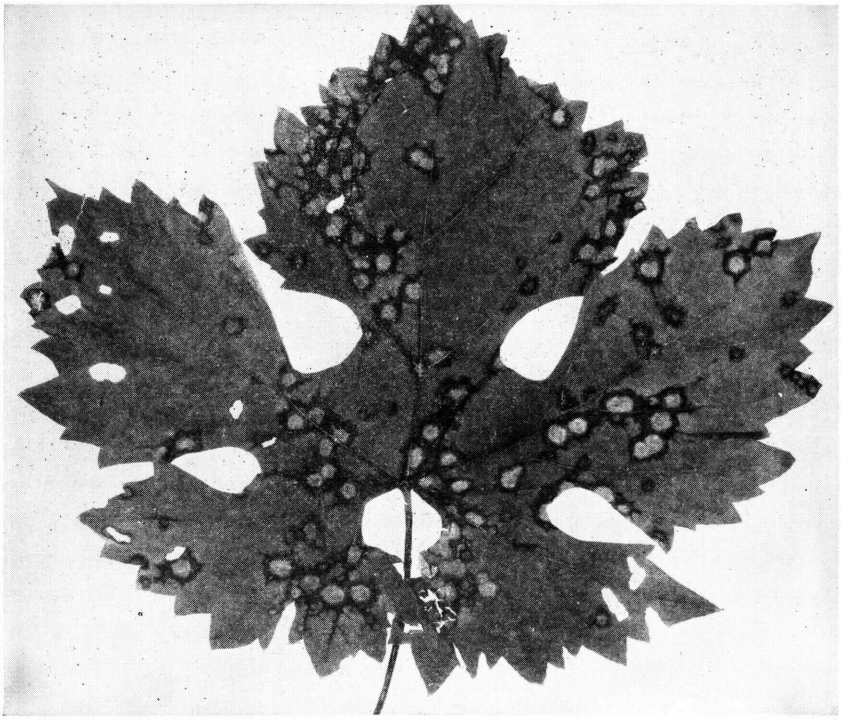

FIGURE 1.—A bunch grape leaf attacked by black rot fungus.

of the berries may occur, depending on the variety, during the period of rapid decay and before drying of the berries takes place. After they become mummified, they are not readily dislodged. The attached dried fruits are covered with very small pimplelike structures that contain spores.

The fungus lives through the winter in a dormant condition, but on the return of warm, moist weather in the spring new spores that infect the young leaves and shoots are produced; thus the rot organism is perpetuated from one season to another. The abundance of the disease from season to season depends on how favorable are the weather conditions during spring and early summer and on the amount of diseased material carried over from the previous season on the vines and fallen leaves and fruits.

Control

If the vines are not sprayed early, the fungus may attack the young shoots and foliage and build up a great reservoir of spores capable of infecting the fruit later in the season. In the South early applications may be necessary to reduce the extent of this early vine infection.

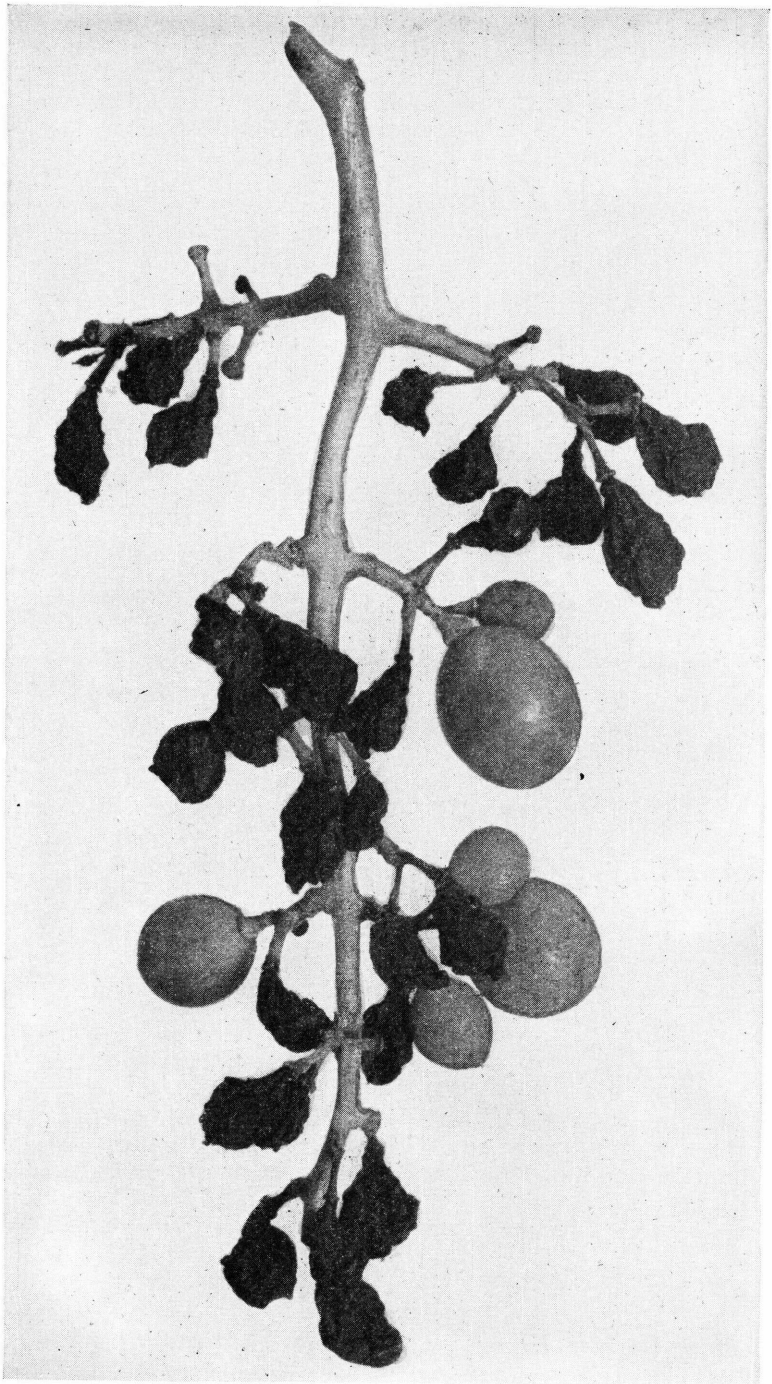

FIGURE 2.—Cluster of grapes showing black rot injury. Note the mummified berries.

In vineyards where black rot has caused considerable loss, and especially in the Southern States, the first application should be made when the new shoots are 1 or 2 inches long, a second application 2 weeks later when the new vine growth is 7 to 10 inches long, and a third application should be made just prior to bloom. In sections, or in vineyards, where the disease does not cause as serious loss, two prebloom sprays, one when new growth is 7 to 10 inches and the second just before bloom, are usually sufficient.

Under average conditions applications of spray immediately before blooming, immediately after blooming, and 7 to 10 days later are essential for satisfactory control of black rot in all vineyards. During unusually wet seasons, an additional application 2 weeks after the 7- to 10-day spray may be necessary, especially if the disease is evident on the fruit at this time. Exact timing of the immediately after bloom application is of utmost importance, especially in seasons when rainfall or dew formation occurs during, or immediately following, the bloom period. The spray schedule on page 36 is meant for average conditions and serves as a guide to the probable number of sprays and the approximate time of application required for protection against grape diseases. Since black rot and some other grape diseases are more destructive in the Southern States, where summer rains are more frequent and the growing season longer, a greater number of applications are required, and it is suggested that readers in those States write to their State agricultural experiment station for detailed information on spray schedules.

DOWNY MILDEW

Downy mildew, caused by the fungus *Plasmopara viticola* (B. & C.) Berl. & De Toni, is primarily a disease of grape foliage. It often becomes quite destructive to the leaves of unsprayed vineyards located in the Ohio River Valley, the Great Lakes region, and northeastern United States as far south as southern Virginia. Since the fungus causing downy mildew is favored by cool, moist weather, the disease is of minor importance in the South. The older leaves in the center of the vine are the first to become infected. The disease spreads from the foliage at the center toward that at the ends of the canes as the leaves mature, and by autumn on highly susceptible varieties even the last leaves formed may succumb, the result being complete defoliation. On the other hand, if the season has been unfavorable for the spread and rapid growth of the fungus or if the variety is resistant, only a few of the oldest leaves may show the disease.

The fungus lives over winter in the old affected leaves on the ground. The action of weathering and decomposition liberates the spores during the spring. By the aid of rain splashing or wind some find their way to the leaves or fruits, where initial infection takes place. Only minor damage is done to the foliage before late summer. The greatest damage occurs during August and September.

The first evidence of infection on the leaves appears as light-yellow spots, as seen from above. Later a white moldy growth, made up of fungus threads and spores, forms on the undersurface of the leaves (fig. 3). The spots may be few or numerous, and by uniting they may involve most of the leaf surface. Invasion of the fungus kills the leaf tissues and then affected portions turn brown. Such leaves finally become dry and crumpled and fall, thus exposing the clusters of fruit

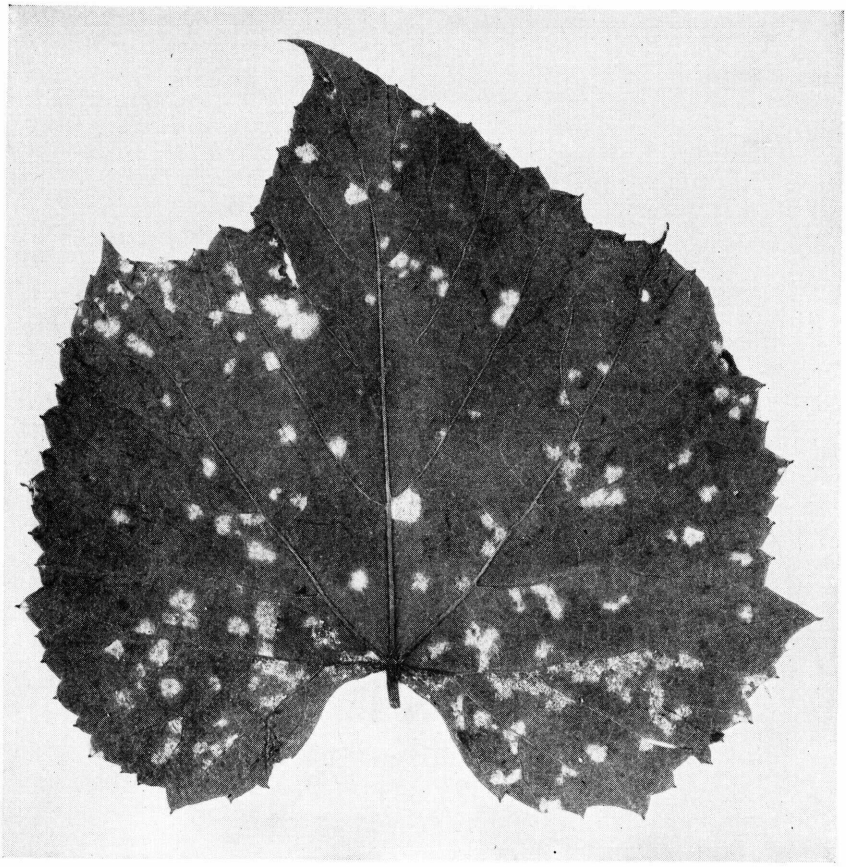

FIGURE 3.—Downy mildew on the under side of a grape leaf.

to burning by the sun. Vines losing their leaves before the ripening season cannot mature the fruit normally; consequently, it is of inferior quality.

The disease may also attack the shoots, tendrils, and fruits (fig. 4). Such parts are attacked early in the season when they are more tender. Infections on the new growth and young fruits show as water-soaked depressions, without any other diagnostic characters, unless there is a development of white moldy growth similar to that on the under side of the leaves.

During years when the fruit is attacked, there may be two waves of infection during the season, the first occurring in June, when the grape berries are about the size of small peas. When the berries are infected at this period they become soft, shatter easily, and are frequently covered with the white, downy growth of the causative fungus (fig. 5). During the hot part of the summer there is less evidence of mildew rot, but upon the approach of cooler nights the second wave of injury may occur. As a rule the fruits infected at this time do not soften and show the downy growth, but instead they become brownish in color, wither, and shatter easily.

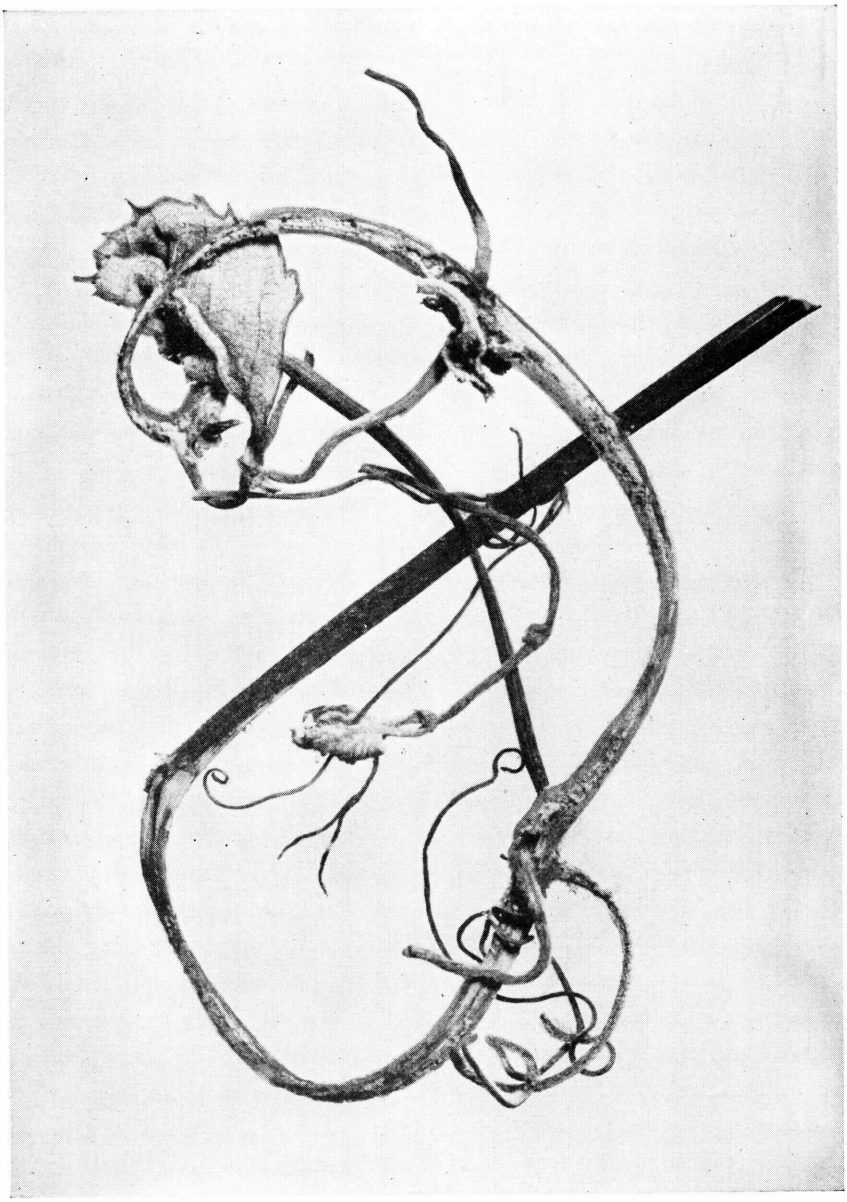

FIGURE 4.—Tips of grapevine killed by downy mildew.

Control

Downy mildew of grapes is comparatively easy to control and seldom does damage in vineyards that are sprayed regularly for protection against black rot, providing bordeaux mixture is used. Ferbam will not control this disease. The spray schedule recommended on page 36, if followed, will effectively control downy mildew.

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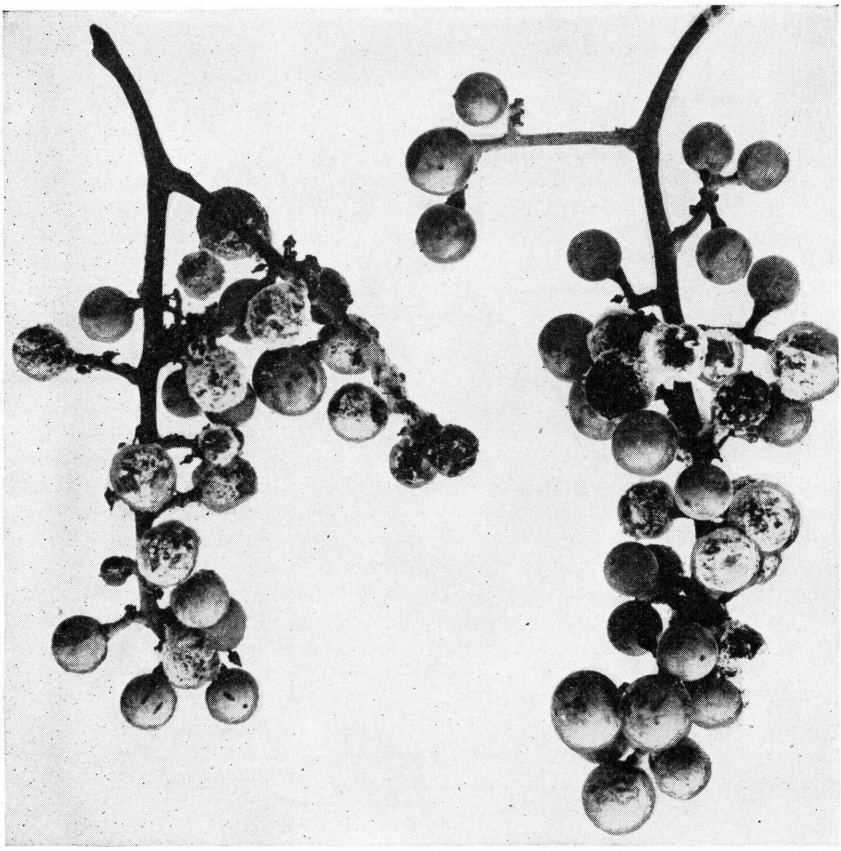

FIGURE 5.—Downy mildew on young grape berries. (Courtesy Department of Plant Pathology, Cornell University.)

ANTHRACNOSE, OR BIRD'S-EYE ROT

Anthracnose, caused by the fungus *Elsinoë ampelina* Shear, occurs in some sections in the eastern half of the country, in both the northern and the southern part, but it is usually localized and confined to a few varieties. It may do considerable damage in a vineyard or a locality for a few years and then disappear.

Anthracnose has seldom been reported on the variety Concord, the most widely grown variety in the Eastern States. Other highly resistant eastern varieties are Beacon, Delaware, Herbemont, Niagara, Moore Early, President, and Lutie. The most susceptible varieties reported are Champion, Catawba, Diogenes, Campbell Early, Diamond, Ellen Scott, Norton, and Salem.

The effect of the disease on the fruit and other parts of the vines is quite striking and not easily confused with other grape diseases. In addition to the fruit, the young shoots, tendrils, petioles, leaf veins, and fruit stems may also be attacked severely.

Numerous spots sometimes occur on the young shoots; some will unite and cause girdling, which results in the death of vine tips. Similar spots develop on the petioles and leaves, especially on the undersurface of leaves. Badly infected leaves curl downward from

the margins, becoming distorted and spotted, and the diseased areas drop out, giving the leaf a ragged appearance.

On the fruit the spots are circular, sunken, and ashy gray in color; in the later stages they are surrounded by a dark-colored margin. The name bird's-eye rot, sometimes applied to this disease, is derived from the appearance of the spots on the berries (fig. 6).

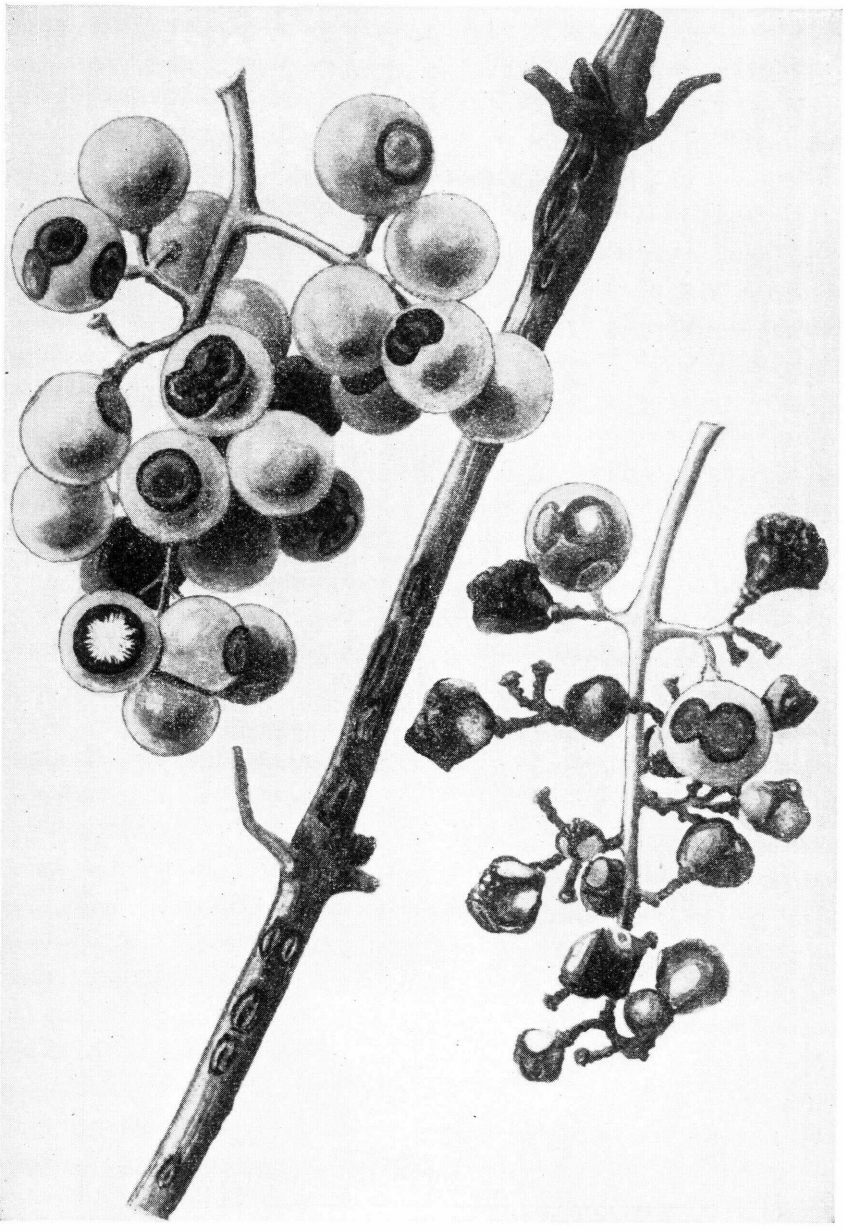

FIGURE 6.—Anthracnose on fruit and vine of grape. (Photographed from painting by J. M. Shull.)

Control

Four or five applications of bordeaux mixture as directed for the control of black rot, in addition to an application of lime-sulfur solution at the strength of 1 gallon of concentrated lime-sulfur to 9 gallons of water during the dormant season, have given good control. It is also advisable to remove and burn all affected parts as they appear.

RIPE ROT AND BITTER ROT

Other rots that appear on the fruits when they begin to mature are known as ripe rot, caused by the fungus *Glomerella cingulata* (Stonem.) Spauld. & V. Schrenk, and bitter rot, caused by the fungus *Melanconium fuligineum* (Scrib. & Viala) Cav. There are no clear-cut diagnostic features by which growers distinguish these two, except that the fungus causing bitter rot imparts a bitter taste to decayed berry pulp.

Control

These diseases are not troublesome in vineyards well sprayed, as recommended for black rot on page 36. Since these diseases do not appear until the grapes begin to mature, the later applications of spray made for control of black rot are especially important for protecting the berries during the ripening season.

DEAD ARM

Dead arm is primarily a disease of the trunk and main branches of the vine. It has been reported from several States in the northeastern part of this country. An epidemic of the disease has rarely been recorded, and the total loss each year is nominal; nevertheless, the disease has been found in many vineyards.

The disease is caused by a fungus (*Cryptosporella viticola* Shear) that attacks the young shoots, the trunk, or branches, gaining entrance frequently through wounds or in parts affected by winter injury. After once entering the woody tissues the fungus lives there year after year as a perennial parasite. The infected tissues are killed, forming a canker that enlarges each year, finally girdling the arm or trunk and causing the death of the portion of the vine above the canker.

If the arm or trunk is girdled, the entire vine above the canker dies and new shoots are put out from the portion below the canker. If the affected branch or trunk is only partially girdled, the new shoot growth developed above the canker will be weak and the foliage dwarfed and curled. If such shoots survive the season, they usually succumb during the following winter.

Control

The dead arm cankers produce innumerable spores capable of starting new cankers elsewhere. Diseased portions of vines should be removed well below the margins of the canker and burned as soon as they are found. Observations in Delaware have shown that a delayed dormant spray with bordeaux mixture early in the spring when the new buds are beginning to open is an aid in preventing new infections with the dead arm disease fungus.

POWDERY MILDEW

Powdery mildew, caused by the fungus *Uncinula necator* (Schw.) Burr., is present in many vineyards but is of small economic importance in the eastern half of the United States. However, it is considered the most damaging fungus disease of vinifera grapes in California.

East of the Mississippi River powdery mildew is very largely a disease of the foliage and cluster stems. It shows on the upper side of grape leaves and other green parts of the vine as a white, powdery, superficial growth (fig. 7). Severely affected leaves turn brown and

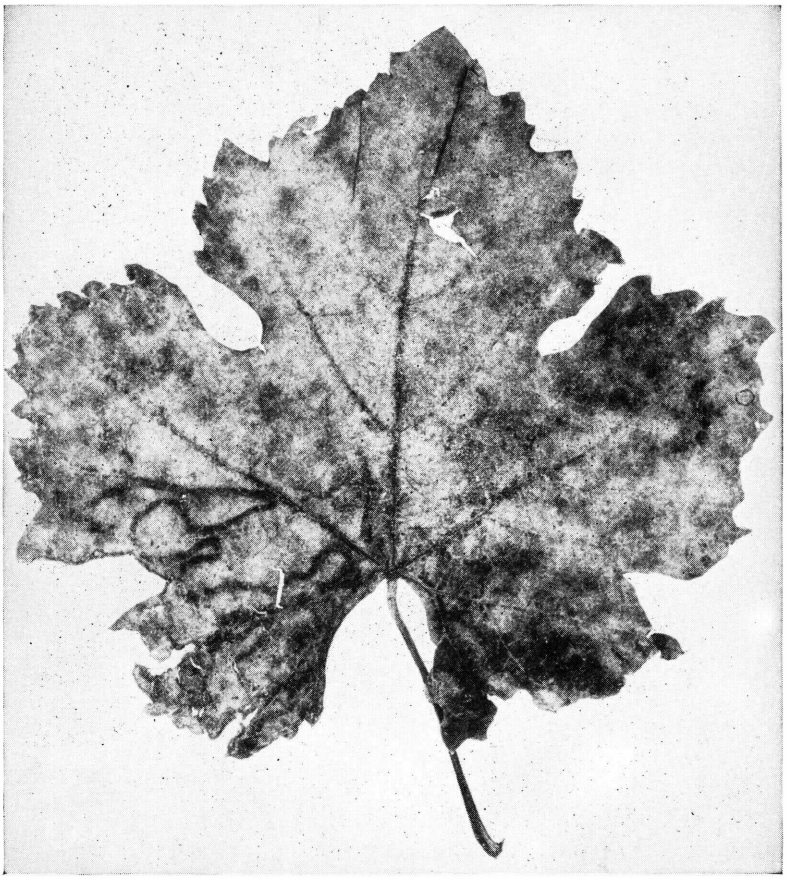

FIGURE 7.—Powdery mildew on the upper side of a grape leaf.

fall. If berries are infected, they have a russeted or scurfy appearance on the surface. They fail to mature properly, but no rot is associated with this injury. Infection of the cluster stem may cause shelling if the harvested fruit is not used immediately.

Control

Powdery mildew is absent in vineyards sprayed for combating black rot and downy mildew; therefore in localities where the disease does damage to either foliage or fruit the spray schedule outlined on page 36 is recommended.

ROOT DISEASES

The roots of grapes are known to be attacked by several different organisms causing either swellings or decay. Root troubles are not easily diagnosed, and it is often necessary to take out a plant or a part of the root system in order to make an examination of suspected root diseases. In general, the symptoms of root diseases are slow growth of the vine; low productivity; small, scant, yellowish leaves; and wilting. Soils known to be infested with the cotton root rot or crown gall organisms should not be planted to grapes. Little or nothing can be done to remedy such troubles after they become established in a vineyard.

Crown Gall

Crown gall, although not a serious grape disease in eastern United States, is conspicuous on the vines when it does occur. This bacterial disease is caused by *Agrobacterium tumefaciens* (Smith & Town.) Conn, and is ordinarily considered to be a wound parasite of the roots and trunk. When the roots are affected, large galls more or less spherical in shape are found, usually near the ground line. Sometimes the galls attain the size of a walnut (fig. 8).

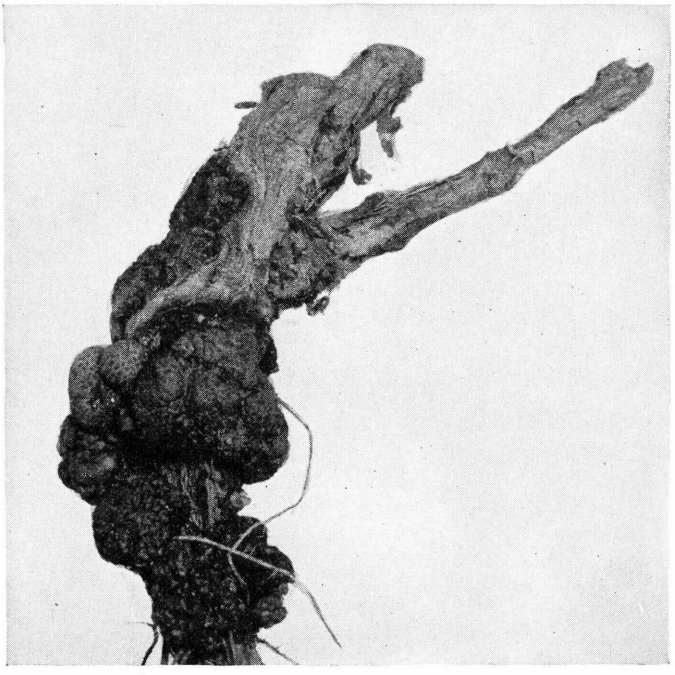

FIGURE 8.—Crown gall on a graperoot at the surface of the soil.

Control

Because the organism producing crown gall lives in the soil, it cannot be controlled by spraying. Where galls are confined to the branches or trunk, these should be removed far enough below the gall to include all affected tissue. New plants can be examined before

planting, and any showing evidence of galls should be discarded. The crown gall organism is widely distributed and attacks various fruit trees and shrubs.

Cotton Root Rot

The cotton, or Texas, root rot disease occurs chiefly in Texas, Oklahoma, and States westward. It is caused by the soil-infesting fungus *Phymatotrichum omnivorum* (Shear) Duggar and attacks the roots of many plants in addition to grape. Conditions favorable for the growth and spread of the fungus are high soil temperature, abundance of moisture, and highly alkaline soils.

A dull yellowish appearance of the foliage and a tendency of the plants to wilt during midafternoons are early symptoms. Badly affected plants may die suddenly; the disease spreads from plant to plant, involving ever-widening circles around the first plant to die. The root system of affected plants shows extensive killing and decay. A network of buff-colored fungus strands is abundant on the surface of diseased or dead roots. During the summer, when frequent rains occur, the fungus produces conspicuous spore mats on the surface of the soil under or near affected vines. At first these spore mats have the appearance of cotton, but later they become buff-colored and powdery.

As stated previously, grapes should not be planted on areas infested by the cotton root rot fungus. The disease is difficult to combat if the causal fungus becomes established in a vineyard; therefore, prompt treatment is essential to prevent rapid spread. An application of ammonium sulfate or ammonium phosphate at the rate of 10 pounds to 100 square feet of soil surface just before a rain if possible or followed by a 3-inch irrigation if available is recommended. The treatment should extend somewhat beyond the area of dead vines.

DISEASES OF MUSCADINE GRAPES

The fruit of the muscadine group of grapes, represented by such varieties as Scuppernong, Hunt, Mish, James, and Thomas, are relatively free of diseases. Black rot, the most damaging disease of the fruit of the American bunch grape, does a negligible amount of damage to the muscadine fruit. Infection by black rot as a rule does not cause decay on muscadines,[2] but results in a black, shallow, hard scablike defect (fig. 9).

The blossoms, however, are susceptible to attack by the black rot fungus. A few days of cloudy, rainy weather during the blossoming period will favor infection and sometimes result in a heavy drop of blossoms. The black rot fungus causes considerable spotting on the foliage of muscadine grapes. In seasons favorable for the fungus, the spots are rather conspicuous and numerous, and a large portion of the leaf area may be destroyed (fig. 10). The foliage of Scuppernong and Mish varieties is very susceptible to this disease.

The bitter rot fungus attacks the fruit during the ripening season and causes some decay and shattering; however, some varieties of the muscadine grapes shatter badly, irrespective of the presence of diseases. In the Southern States this disease causes greater loss of fruit in muscadine vineyards than any other disease.

[2] The fungus that causes black rot in muscadine grapes is known as *Guignardia bidwellii* f. *muscadinii* Lutrell and does not affect American bunch grapes.

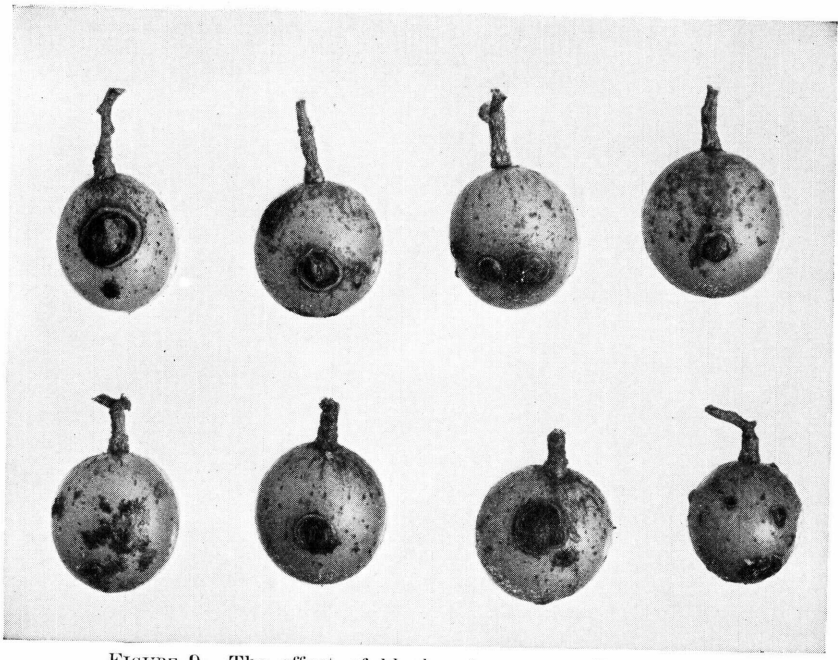

FIGURE 9.—The effect of black rot on muscadine grapes.

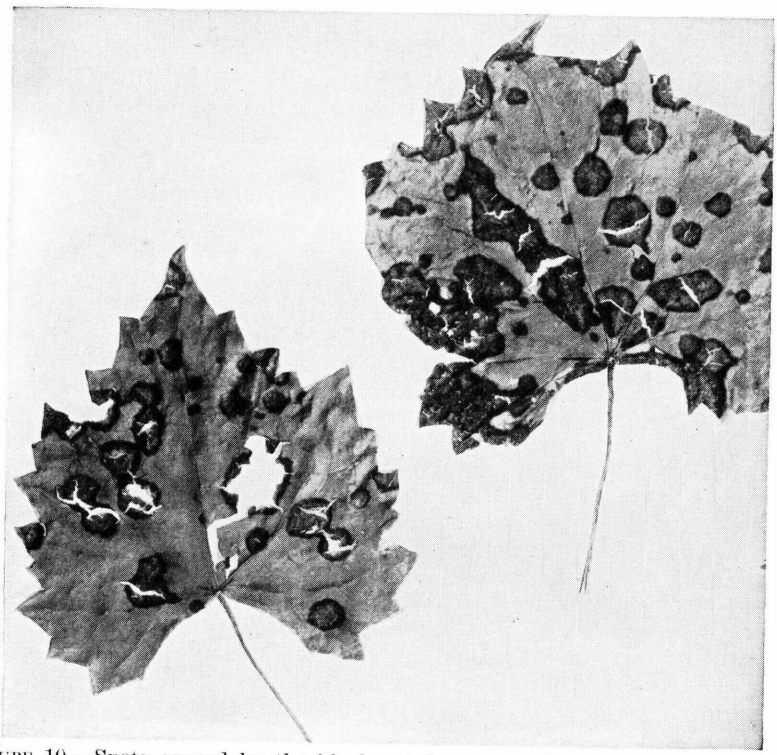

FIGURE 10.—Spots caused by the black rot fungus on leaves of the muscadine grape.

CERCOSPORA, OR ANGULAR, LEAF SPOT

Cercospora, or angular, leaf spot, caused by the fungus *Mycosphaerella angulata* Jenkins, is the most important foliage trouble on muscadine grapes. All commonly grown varieties are susceptible, although Flowers, Scuppernong, and Thomas are more resistant than Creek, Howard, Hunt, and Stuckey. The causative fungus does not attack the berries.

The disease first shows as angular, or irregular, brown spots surrounded by a light-yellowish halo on the upper leaf surface. The spots enlarge and some combine, involving a considerable portion of many leaves. Under humid conditions a great number of spores form on both leaf surfaces, but they are more abundant on the lower side and show as a light-olive color. The spores are washed away by rains when the spots, especially on the under leaf surface, are black and with some magnification appear pimply (fig. 11). As the result of severe

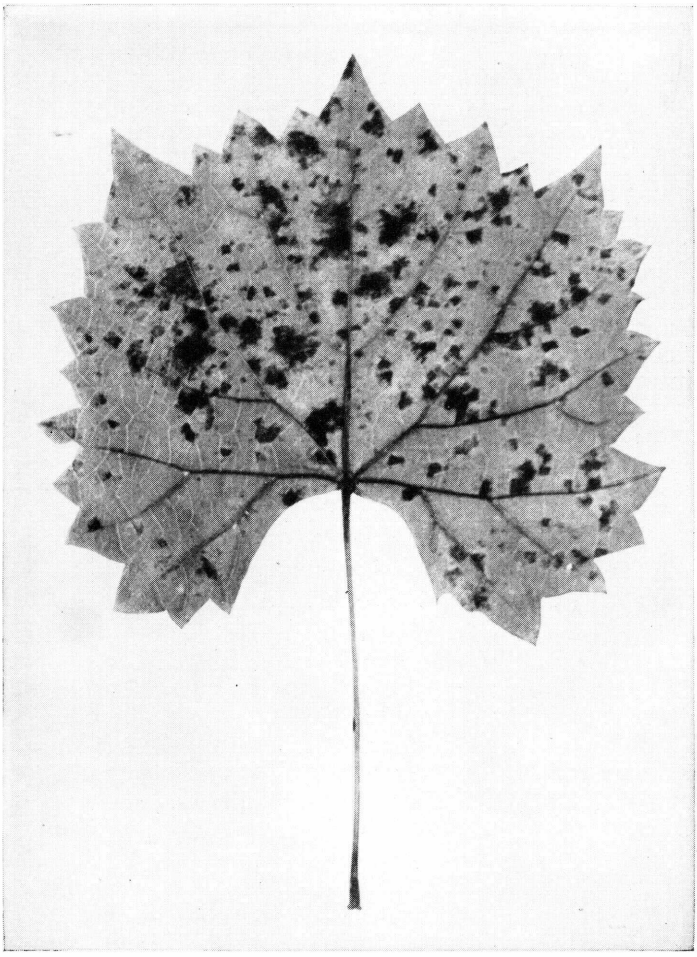

FIGURE 11.—A muscadine grape leaf spotted by Cercospora.

infection on the more susceptible varieties, defoliation occurs, causing impairment in quality of the berries.

Control

Very little is known concerning appropriate control measures for Cercospora leaf spot. Some work done at the Georgia Agricultural Experiment Station indicates that the disease may be easily controlled by applying bordeaux mixture at 2- to 3-week intervals during the first half of the growing season. Fungus spores that start the early spring infections live over winter on the old, fallen leaves. A great amount of this infectious material could be eliminated by plowing under the old leaves prior to the formation of the new spring foliage.

INSECTS

GRAPE BERRY MOTH

Grapes are frequently injured by the larva of the grape berry moth (*Polychrosis viteana* (Clem.)), an active greenish caterpillar about three-eighths inch long when full-grown. Larvae of the first brood of this pest feed in the blossoms or very young fruit clusters and in the newly formed berries. Those appearing later injure the green and ripening berries (fig. 12, *A*), often causing serious losses. One larva may injure several berries. On completing their feeding, the caterpillars leave the berries and each cuts out a small bit of leaf, folds it over, and constructs a cocoon within the fold (fig. 12, *B*). The leaf folds containing the cocoons may remain attached to the leaves or they may break off and fall to the ground. Caterpillars of the first brood usually construct their cocoons on the grape leaves on the vine during June or July. Those of the second brood usually drop to the ground and form their cocoons on small pieces of leaves under the grape trellis (fig. 12, *C*).

The insect overwinters in the cocoon (fig. 12, *D*). Late in the spring or early in the summer the inconspicuous brownish moths (fig. 12, *E*) emerge and lay their eggs on the grape stems or berries.

The grape berry moth is found over most of the eastern half of the United States and is especially troublesome in the area north of the Ohio River, east of the Mississippi River, and on through New England.

Control

To control the grape berry moth a combination of methods is suggested. In vineyards in northern Ohio certain cultural practices aid in lowering the overwintering population to the point where a reduced spray schedule will give good control or a given spray schedule will give better control than it would otherwise.

In the preferred method of cultural control a low ridge of soil is thrown under the trellis, with a grape hoe, disk, or plow, 30 to 45 days before harvest. The ridge should be flat and wide and the row center almost level. The overwintering cocoons (fig. 12, *D*), which later accumulate on top of the ridge, will be exposed to natural destructive agencies during the winter. In the spring the ridge is pulled out into the row centers and the centers are then disked to cover the cocoons. A shallow compact covering about 1 inch thick will prevent

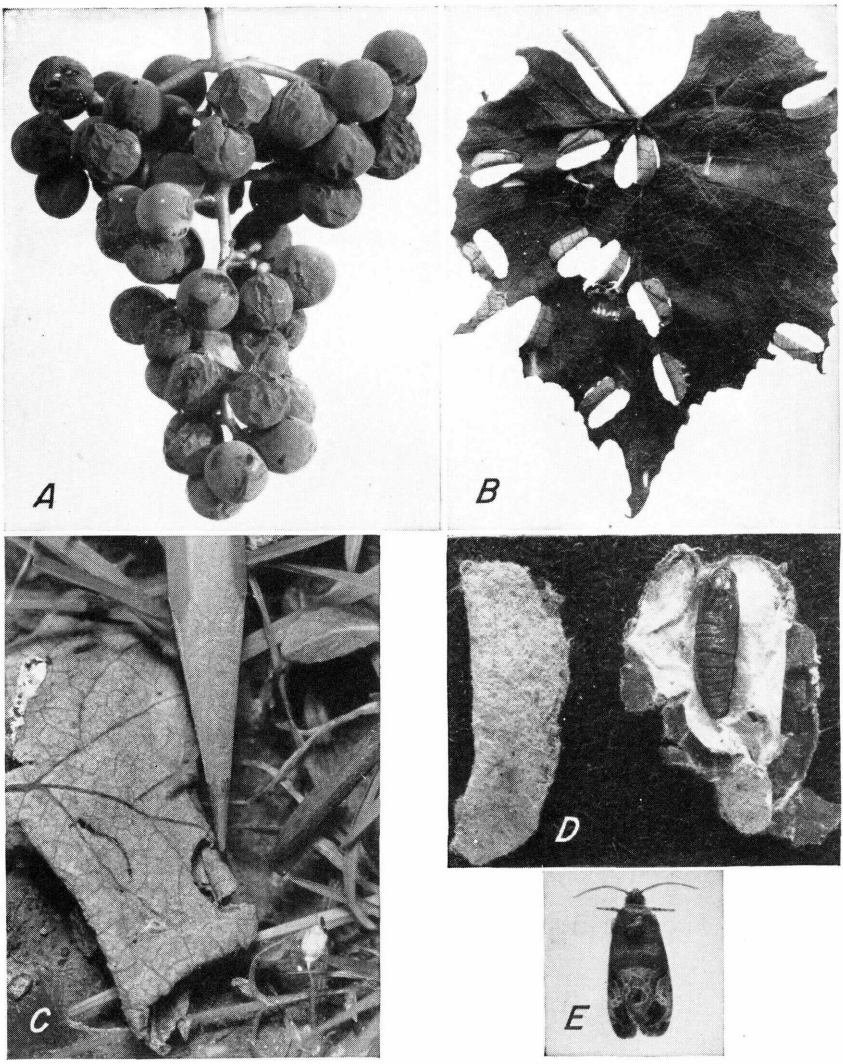

FIGURE 12.—*A*, Cluster of grapes injured by grape berry moth; *B*, cocoons of moths on a fallen grape leaf (the cocoons are hidden under the small flap of leaf material cut and turned over); *C*, overwintering cocoon of grape berry moth (indicated by pencil point) on surface of ground under trellis; *D*, cocoon and pupa within an opened cocoon (about 3 times natural size); and *E*, adult (about 3 times natural size).

moth emergence. If preferred, the soil can be thrown toward the grape trellis in the spring to form a smooth, compact covering over the cocoons underneath. With either method the operation should be completed at least 15 days before the average date of grape bloom and the covering (fig. 13) left undisturbed until at least 15 days after grape bloom.

In addition to the cultural treatment, a DDT spray should be applied (1) immediately before or immediately after grape bloom, (2)

FIGURE 13.—Cultipacking grape rows after early spring cultivations of grapes to cover overwintering cocoons of the grape berry moth with a light compact covering of soil to prevent the moths from emerging.

10 to 15 days after grape bloom, (3) 35 to 45 days after bloom, and (4) 10 to 15 days later. The last spray should be applied at least 30 days before grape harvest to avoid excessive spray residues on the fruit. The spray should contain 1½ pounds of 50-percent DDT wettable powder per 100 gallons and should be used at the rate of 200 to 300 gallons per acre, depending upon the density of the foliage. Fewer applications may be adequate in vineyards in which the berry moth is not a serious problem. A fungicide for control of diseases may be combined with the berry moth spray. A sticker (p. 35) may be used with the two early sprays, but it should be omitted in the late sprays to reduce the residue on the fruit at harvest. (See general spray program, p. 36, and precautions, p. 34.)

GRAPE LEAFHOPPERS

Grape leafhoppers (*Erythroneura comes* (Say) and related forms) are often abundant during the summer on the lower surface of grape leaves (fig. 14, *B* and *C*). They are small, agile, white or pale-yellow insects with red or yellow markings. They feed by sucking juices from the leaves, causing them to become blotched with white (fig. 14, *A*) and later to turn brown; many leaves fall from the vines prematurely. This injury prevents normal vine growth and interferes with the proper ripening of the fruit.

The insects pass the winter in the adult stage in protected places, usually in trash on the ground in, or close to, vineyards. With the first warm days of spring the leafhoppers become active and feed on any green vegetation they can find, but concentrate on the grape leaves as soon as these push out. Eggs are laid in the leaf tissue. There are two or three generations of these insects each season.

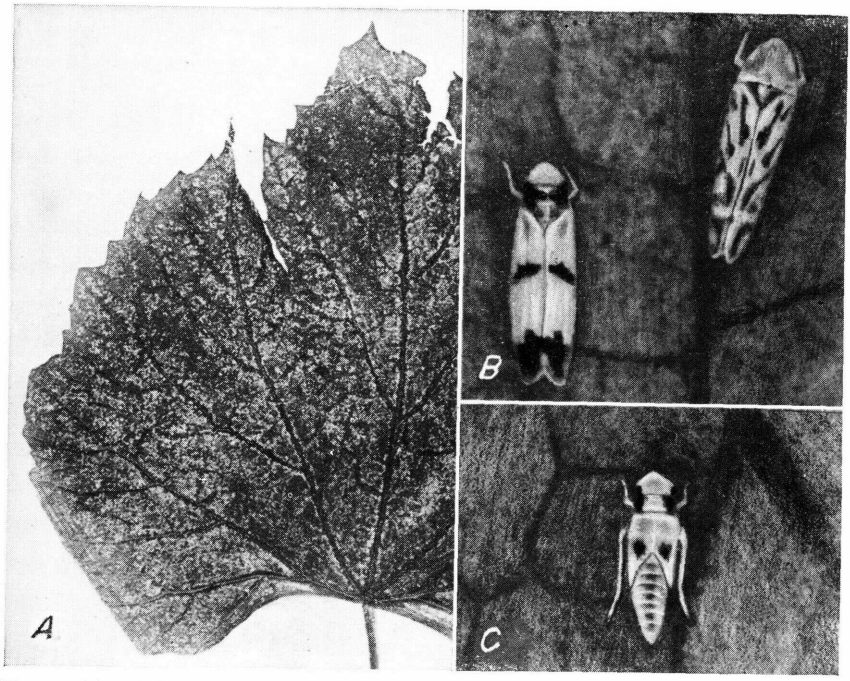

FIGURE 14.—*A*, Mottled appearance of grape foliage injured by grape leafhoppers; *B*, adult leafhoppers; *C*, nearly full-grown nymph. Insects about 10 times natural size.

Control

The grape leafhopper may be controlled by spraying with DDT. In the Eastern States one thorough application of a DDT spray immediately after bloom is usually sufficient. The 50-percent DDT wettable powder is used at a strength of 1½ pounds per 100 gallons. If a DDT spray schedule is used for controlling other grape insect pests, the leafhoppers will be controlled at the same time. In case overwintering leafhoppers are extremely abundant early in the spring and are seriously injuring the new grape shoots, it may be advisable to make a special application of DDT at this time to prevent serious injury to the growing shoots.

GRAPE ROOTWORM

The grape rootworm (*Fidia viticida* Walsh) infests the roots of the grape (fig. 15, *A*), devouring more or less completely the small roots and rootlets and eating pits and burrows into the outer portion of the larger roots. The adult, a small, hairy, chestnut-brown beetle, appears in vineyards of such varieties as Concord, Niagara, and Catawba shortly after the blooming period. The beetles feed on the upper surface of the leaves, eating a series of patches or holes through to the lower surface that take the form of characteristic chainlike feeding marks (fig. 15, *B*). The injury to the foliage, however, is unimportant compared with the work of the larvae on the roots.

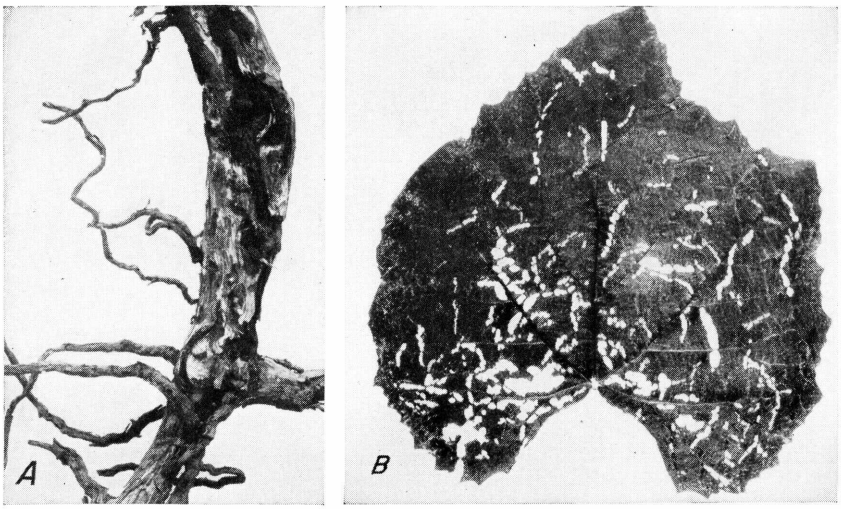

FIGURE 15.—*A*, Injury done by larvae of grape rootworm to roots of a grapevine; *B*, feeding marks made by beetles on a grape leaf.

Control

The grape rootworm may be controlled in the adult, or beetle, stage by spraying the foliage and vines with 1½ pounds of 50-percent DDT wettable powder in 100 gallons of water when the first feeding injury is noted on the grape leaves. The first and second sprays applied for berry moth control usually control the grape rootworm. If they do not, an additional spray should be applied about 10 days after the second application.

ROSE CHAFER

In some localities in the eastern United States the rose chafer (*Macrodactylus subspinosus* (F.)) causes severe injury early in the season to grape foliage, blossoms, and newly set berries (fig. 16). The beetles are general feeders and injure many kinds of fruits and ornamental plants. They sometimes fly into the vineyard in large numbers and consume most of the foliage, leaving only the larger veins. Their feeding period lasts from 3 to 4 weeks.

This insect breeds largely in light sandy soils. In the larval stage it is a small white grub.

Control

Effective control of the rose chafer can be obtained with an application of a spray containing 2 pounds of 50-percent DDT wettable powder per 100 gallons. It is important that the spray be applied as soon as the beetles appear, as they can do considerable damage in a 24-hour period. This means that it may sometimes be necessary to spray while the grapes are in bloom. More often a spray to control the rose chafer will be needed near the time for the first application to control the grape berry moth. If so, a single application will suffice for both insects. A fungicide may be added to this spray for disease control.

LEAF-EATING CATERPILLARS

Many different kinds of caterpillars feed on grape leaves.

The grape leaf folder (*Desmia funeralis* (Hbn.)) is an active, grass-green caterpillar about three-fourths of an inch long, which rolls or folds the leaves (fig. 17) and then feeds within the shelter thus formed.

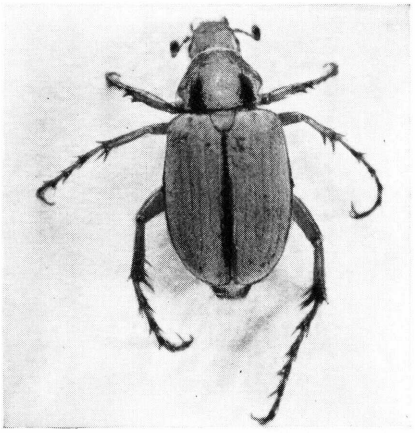

FIGURE 16.—Adult female rose chafer. About 3 times natural size.

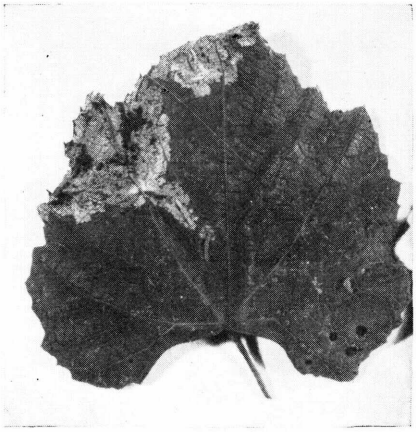

FIGURE 17.—Injury to grape leaf caused by the grapeleaf folder.

The larva of the eight-spotted forester (*Alypia octomaculata* (F.)) is a little more than an inch long, and has black and orange stripes across the body and a distinct hump near the hind end (fig.18).

Several species of hornworms, large caterpillars from 2 to 3½ inches long, often injure grape leaves, sometimes completely defoliating the vines. One of them, the achemon sphinx (*Pholus achemon* (Drury)), is illustrated in figure 19.

Control

The leaf-chewing caterpillars are usually controlled by the second, third, or fourth applications referred to in the spray program on page 36. As DDT does not control all species of these caterpillers, the addition of lead arsenate at 3 pounds per 100 gallons to one of the regular DDT sprays is usually sufficient to control them. To prevent excessive lead and arsenic residue on the grapes, no lead arsenate should be applied later than 3 weeks after grape bloom.

In small plantings most of the leaf-eating caterpillars may be controlled by hand picking.

GRAPEVINE APHID

In vineyards east of the Mississippi River large numbers of the grapevine aphid (*Aphis illinoisensis* Shimer) are often found during the summer on the young shoots and leaves (fig. 20). This tiny, dark-brown aphid is most likely to appear in dry weather and often disappears almost completely after a heavy rainstorm. When the aphids are very abundant, they may infest the fruit clusters, causing

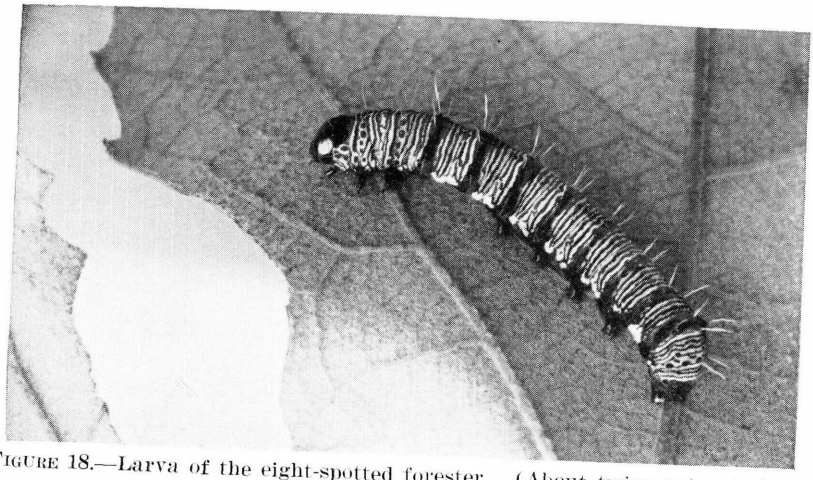

FIGURE 18.—Larva of the eight-spotted forester. (About twice natural size.)

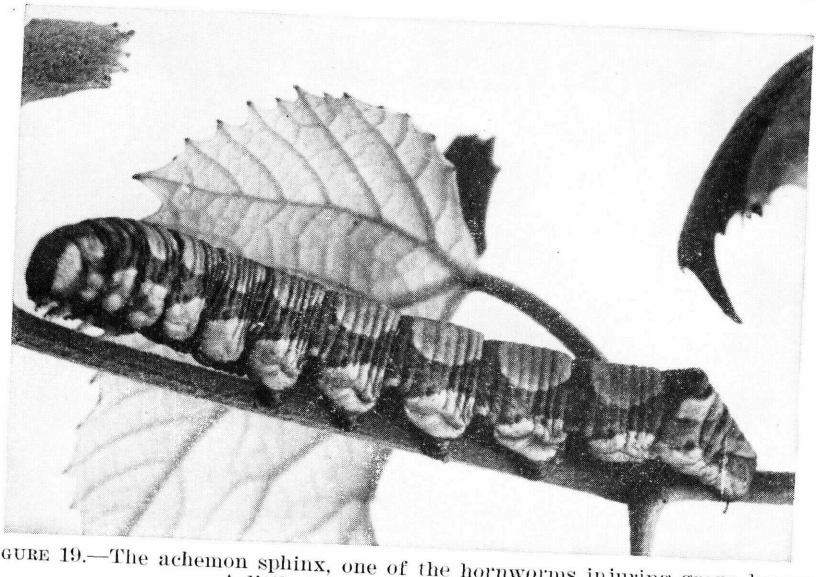

FIGURE 19.—The achemon sphinx, one of the hornworms injuring grape leaves. A little larger than natural size.

some of the grapes to drop. In the fall the aphids leave the grapevines and migrate to the blackhaw, where they spend the winter and spring months, returning to the grapevines early in the summer.

Control

The grapevine aphid may be controlled by spraying the vines with a contact insecticide after the insects appear. For this purpose 1 pint of nicotine sulfate (40-percent nicotine) in 100 gallons of water may be used. Either a small quantity of soap should be added or the nicotine sulfate should be combined with bordeaux mixture in one of the regular spray applications. Parathion may also be used at a strength of 1 pound of the 15-percent wettable material per 100 gallons, in combination with one of the regular spray applications.

FIGURE 20.—The grapevine aphid on grape shoots and young leaves.

Parathion is a dangerous material to handle. Before using it, read and observe all caution statements on labels, in packages, and in this bulletin (p. 34).

RED-BANDED LEAF ROLLER

Grapes may be damaged by the larvae of the red-banded leaf roller (*Argyrotaenia velutinana* (Wlkr.)), a greenish caterpillar about three-quarters inch long when full-grown. The caterpillars spin webbing in the grape clusters and feed on the grape berries while being protected by the web (fig. 21). The first brood of caterpillars may be present as early as April, and there are usually two or three broods each year.

Control

Sprays applied just before or after grape bloom reduce damage caused by later broods without leaving excessive harmful residues on the berries. The red-banded leaf roller is not readily controlled with

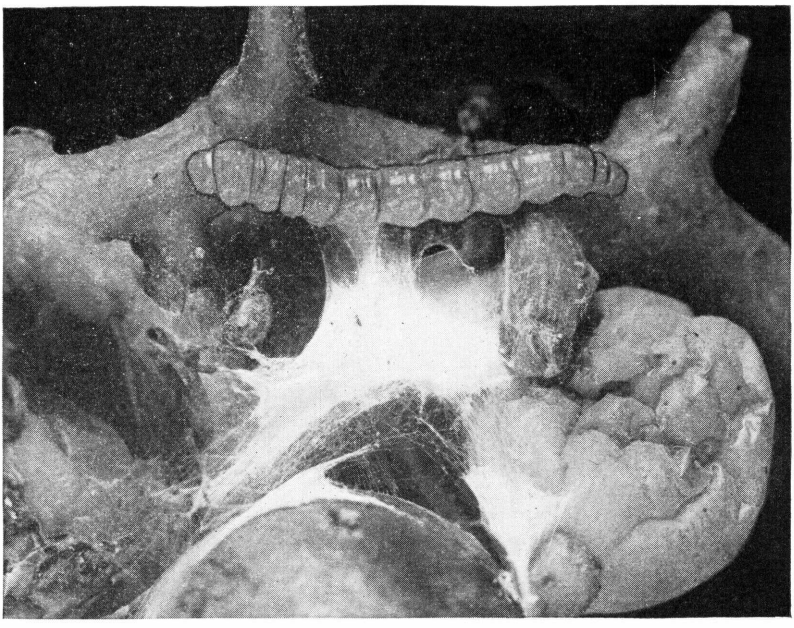

FIGURE 21.—Larva of red-banded leaf roller on a grape stem. About 4 times natural size.

DDT. Therefore, when this insect is a problem, 3 pounds of lead arsenate or 2 pounds of 15-percent parathion wettable powder per 100 gallons should be included in the regular second or third applications as given in the schedule on page 36. Either material may be used in combination with DDT.

Parathion is a dangerous material to handle. Before using it, read and observe all caution statements on labels, in packages, and in this bulletin (p. 34).

CLIMBING CUTWORMS

Several species of climbing cutworms (*Feltia* sp., *Agrotis* sp., and others) attack and destroy grape buds just as they begin to swell in the early spring. The worms eat the bud or eat holes in the buds (fig. 22). Usually this is done at night when the worms come out from hiding under stones, rubbish, or weeds under the grape trellis and climb up the vines. Damage is usually confined to localized areas in a vineyard and seldom occurs after the grape shoots begin to develop.

Control

The best way to protect grapes from cutworm injury is to place a small handful of 10-percent DDT dust on the lower part of the vine and on the ground below. Gloves should be worn while applying the dust. The cutworms contact the DDT as they climb on the vine and are killed by it. Other measures that will reduce cutworm damage include (1) application of a spray containing 2 pounds of 50-percent DDT wettable powder per 100 gallons just as the buds are swelling and (2) early cultivation under the vines in the infested part of the vineyard.

GRAPE FLEA BEETLE

The adult form of the grape flea beetle (*Altica chalybea* (Ill.)) is a dark-blue, shiny beetle about three-sixteenths inch long (fig. 23). It overwinters in the adult stage in debris in or near vineyards. Early in the spring, just as grape buds are swelling, it migrates to the grapevines and kills the buds by eating out the centers. As the secondary grape shoots develop the beetles lay eggs, and the worms, about one-fourth inch long when full-grown, feed on the upper surface of the grape leaves. This insect usually occurs in local areas within a vineyard, especially near woods or buildings. The injury to the grape

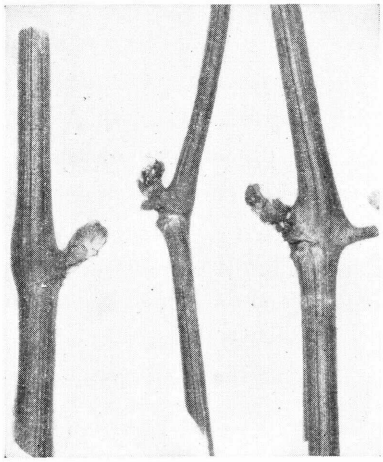

FIGURE 22.—Grape buds (two on right) destroyed by climbing cutworms. Bud on left is not damaged. A little larger than natural size.

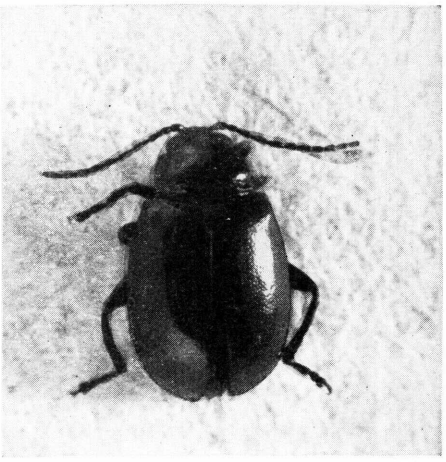

FIGURE 23.—Adult grape flea beetle. About 8 times natural size.

buds closely resembles that caused by climbing cutworms, and examinations should include observations for the insect causing the damage.

Control

A spray containing 2 pounds of 50-percent DDT wettable powder per 100 gallons, applied just as the buds are swelling or when the shoots are 6 to 8 inches long, will control the adult beetles or the immature worms, whichever are present.

GRAPE MEALYBUG

The grape mealybug (*Pseudococcus maritimus* (Ehrh.)) is a whitish insect that sucks juices from the canes, stems, and berries of the grapevine (fig. 24). There are two broods each year. Eggs are laid early in the fall, in a cottony mass under the loose bark of the grape trunk. The eggs hatch in the fall, but the young mealybugs do not leave the cottony protection until early in the spring. They then crawl out from under the bark and up onto the developing grade buds and shoots. These insects mature early in the summer, and a second brood is started, which feeds mainly on the grape clusters. Mealybugs secrete a sweetish honeydew fluid (fig. 25) in which a sooty mold develops, giving the grapes an objectionable appearance and flavor. Injury by mealybugs also causes the cluster stems and grape berries to shrivel and fall.

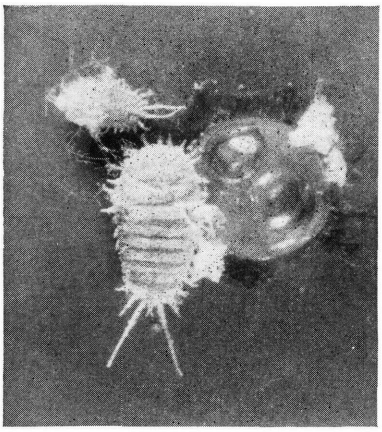

FIGURE 24.—Grape mealybug (immature) feeding at junction of pedicle and grape berry. About 8 times natural size.

Control

A single spray application of 2 pounds of 15-percent parathion wettable powder per 100 gallons of water will give adequate control of the grape mealybug. The spray may be applied 2 weeks before grape bloom or 6 to 8 weeks thereafter, but not later than 21 days before harvest.

Parathion is a dangerous material to handle. Before using it, read and observe all caution statements on labels, in packages, and in this bulletin (p. 34).

JAPANESE BEETLE

The Japanese beetle (*Popillia japonica* Newm.) (fig. 26, *A*) is a shiny, metallic-green beetle less than half an inch long, with coppery-brown wing covers. It may begin to appear on grapes early in the summer, about June 1 in parts of Virginia, June 15 in the vicinity of Philadelphia, and July 1 or later in New England. For 4 to 6 weeks the beetles may feed heavily on grape foliage (fig. 26, *B*), particularly the part directly exposed to the sun, giving the foliage a lacelike appearance. Badly injured leaves soon drop. The eggs are laid in the soil, most commonly in grassy areas, where the grubs develop.

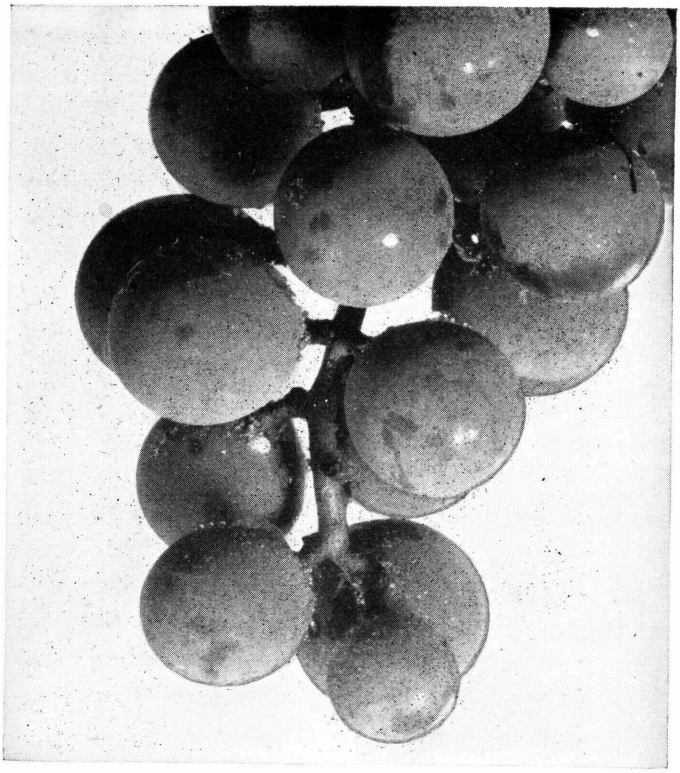

FIGURE 25.—Honeydew secretion on grape berries caused by feeding of grape mealybugs. About twice natural size.

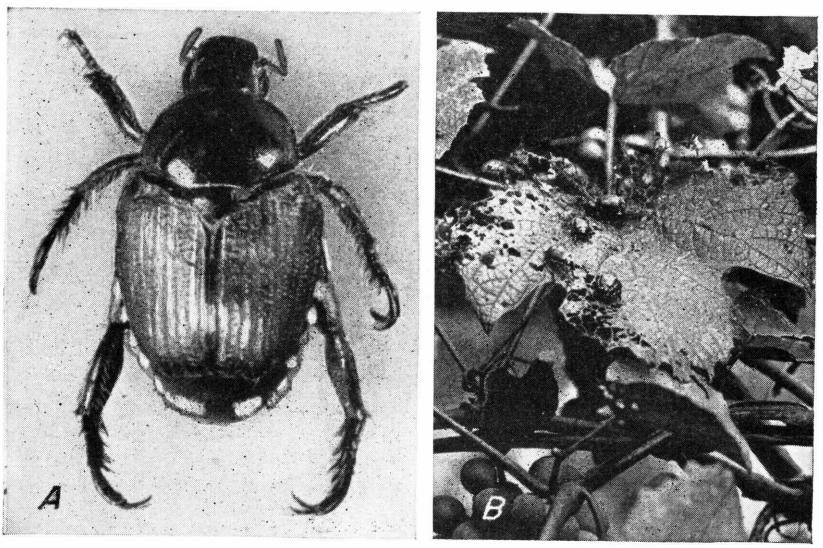

FIGURE 26.—Japanese beetle: *A*, Adult, enlarged; *B*, beetles feeding on a grape leaf.

Control

Vineyards can be protected by spraying the vines thoroughly with 2 pounds of 50-percent DDT wettable powder per 100 gallons when the beetles appear and at such intervals thereafter as new growth requires protection. Ordinarily the DDT sprays applied to control the grape berry moth will take care of the Japanese beetle at the same time. No DDT should be applied later than 30 days before grape harvest. On early-maturing grapes, which may need protection closer to harvest than 30 days, a spray containing 3 pounds of derris or cube (rotenone 4 percent) in 100 gallons of water will repel the beetles for a few days. Dusting with hydrated lime will also prevent some feeding.

GALL MAKERS

Swellings, or galls, of various kinds occur on grapes as a result of attack by several unrelated insects. Any part of the plant may be affected, but as a rule injury is not great.

Leaves covered with galls, as in figure 27, indicate an infestation by the grape phylloxera (*Phylloxera vitifoliae* (Fitch)), a small, aphid-like insect that attacks both roots and foliage. Root damage is especially serious on vinifera varieties of grapes, such as are commonly grown in California. Wild grapes in the East and varieties developed from them possess varying degrees of immunity from injury and thrive despite the presence of the insect. The leaf galls are common on some varieties of grapes in the East, but are rarely found in the West.

The term "tomato gall" is used to describe masses of irregular, succulent galls often found on wild and cultivated grapes (figs. 28 and 29). They are caused by tiny insects known technically as *Lasioptera vitis* O. S. and *Dasyneura vitis* Felt. The galls may be on the leaves, leafstalks, tendrils, or stalks of the fruit clusters and vary in color from greenish yellow to reddish. They are divided into tiny cells in each of which there will be, at the proper time, an orange-yellow larva, or grub. The adults are tiny flylike insects known as gnats, or midges. They appear in the spring in time to attack new, tender growth.

Pear-shaped, hazelnutlike galls (fig. 30), less than an inch in diameter, which are greenish at first and become reddish as the season advances, are caused by the grape apple gall maker (*Schizomyia pomum* W. & P.). These galls are marked on the outside with depressions extending lengthwise and are divided into cells in which the bright-yellow larvae develop.

An enlargement on the cane, usually just above a lower joint, about twice the diameter of the cane and 1 or 2 inches long, may result from puncture by the grape cane gall maker (*Ampeloglypter sesostris* (Lec.)), a small, reddish-brown weevil. An egg is placed in this puncture, and several additional punctures may be made above the original one, but no additional eggs are deposited. The larva feeds in the pith, burrowing up and down the shoot. The beetles emerge in midsummer. The injured canes continue to grow and become enlarged at the punctured place, but unless they are broken little harm results.

Grape leaves sometimes have the upper surface more or less covered with slender galls, about one-third inch long and reddish to crimson in

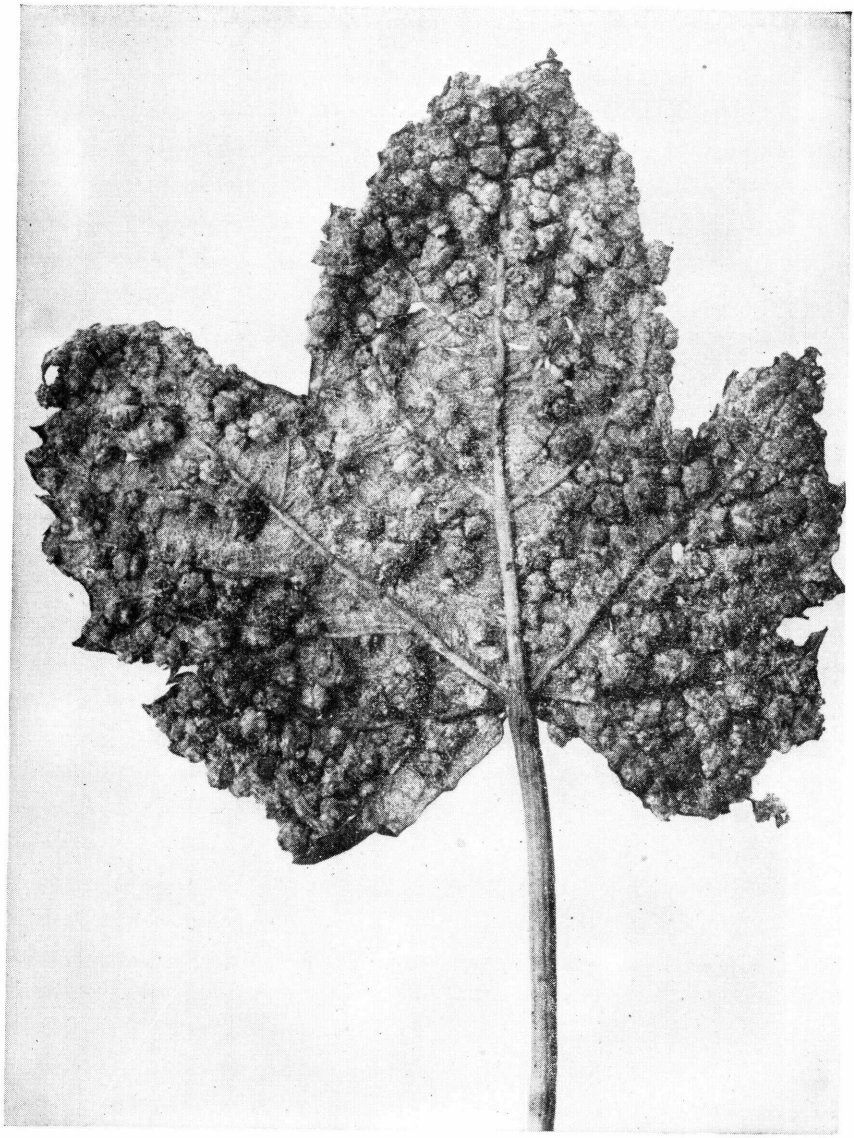

FIGURE 27.—Leaf galls of grape phylloxera.

color, shading to green. These trumpet, or grape tube, galls are caused by a small midge, or gnat, known as *Cecidomyia viticola* O. S. The larva, or grub, within the gall is pale orange.

Control

No spray treatments are known that will prevent or control an infestation of any of the grape gall makers. Growers of American varieties of grapes will seldom find the grape phylloxera of sufficient importance to require control measures; growers of vinifera varieties should plant only vines grown on resistant rootstocks. Cutting off

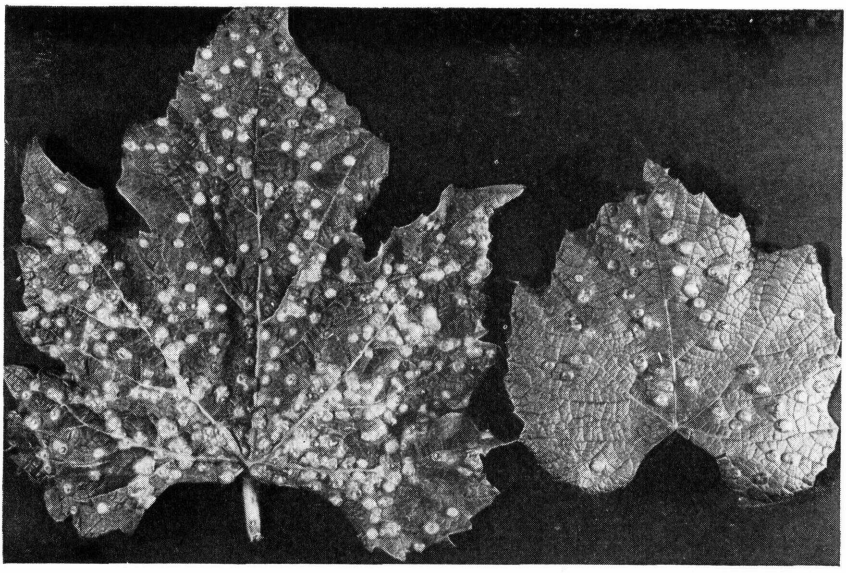

FIGURE 28.—Grapevine tomato galls on grape leaves.

and destroying affected parts before the grubs escape should reduce the numbers of the grapevine tomato gall another season. Removal by hand and destruction of the galls is the only known means of combating the grape apple gall. Although no practical method of controlling the grape cane gall maker or the trumpet, or grape tube, gall midge is known, there is seldom need for control.

BEES AND WASPS

Bees attack the grape through injuries caused by other insects or diseases, or through splits in the skins of overripe berries. They are not able to break the skins of sound grapes with their mouth parts. When the skin has been broken, bees may quickly reduce the fruit to a worthless condition. Injury by bees can best be avoided by controlling other insects and diseases that cause skin injuries and by picking the grapes before they are overripe. In small home vineyards bunches of grapes can be protected with cheesecloth or paper bags put on just before the grapes begin to ripen.

Wasps may also be attracted to overripe or injured grapes. Bagging protects the bunches from attack by wasps.

GENERAL RECOMMENDATIONS FOR GROWING SOUND FRUIT

DISEASE-RESISTANT VARIETIES SUITABLE FOR HOME GARDENS

The standard varieties of bunch grapes grown in eastern United States are important commercially not only because they possess excellent table qualities, are suitable for making juice or wine, or are especially adapted to certain soils and climates, but also because their diseases and insect pests can be successfully controlled without much trouble and expense.

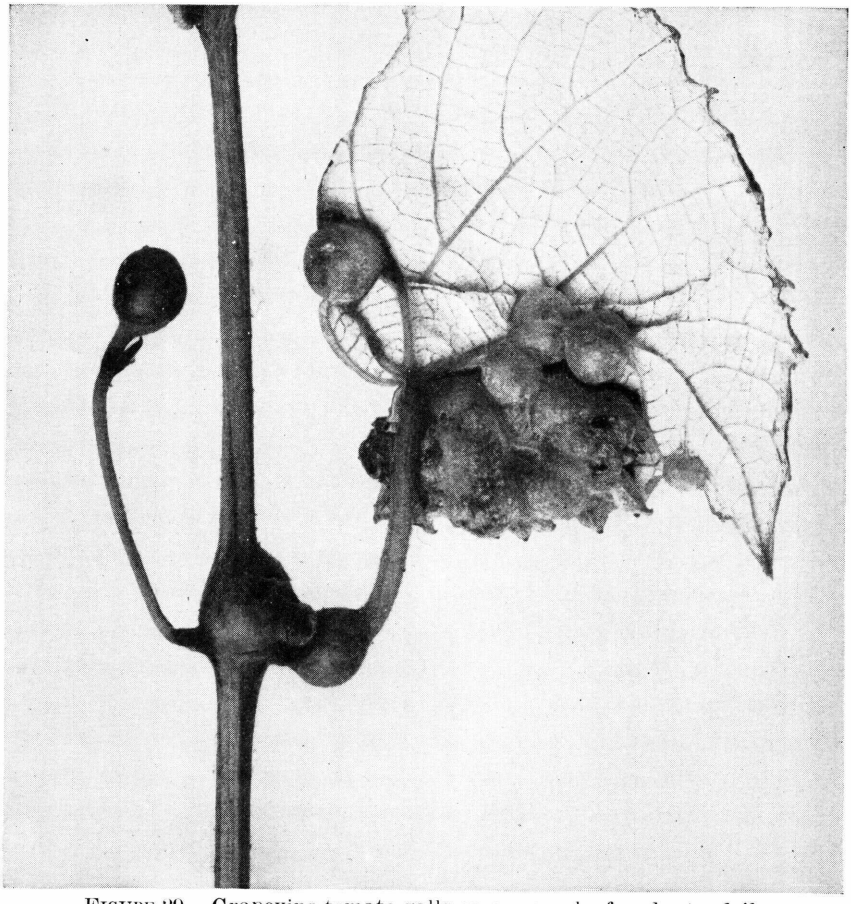

FIGURE 29.—Grapevine tomato galls on a grape leaf and a tendril.

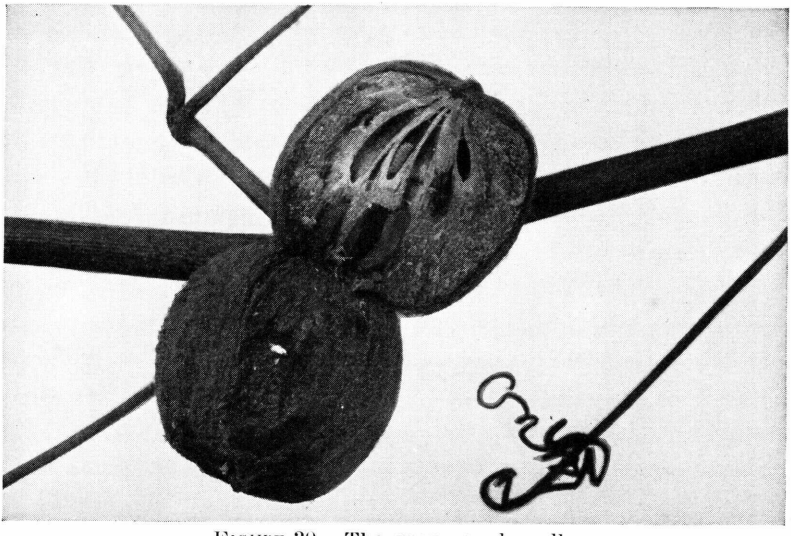

FIGURE 30.—The grape apple gall.

Under field conditions, where the vines are pruned regularly, sanitary measures are practiced, and spraying is properly done when needed, diseases cause very little concern to the growers. Often, the same varieties, grown in home gardens where the vines are crowded, shaded, and indifferently pruned, will be diseased badly, even if sprayed frequently. It is advisable sometimes for those wishing to grow a few grapes in a garden plot to select varieties primarily from the standpoint of disease resistance, with some sacrifice of quality of fruit. There are a few varieties of fair to good quality that can be grown, at least in the Northeastern States, with little or no spraying. The variety Lutie would be worth trying. It is productive, the fruits are large and of fair quality, and it is resistant to black rot and downy mildew. In districts where downy mildew need not be considered, the varieties Campbell Early, Delaware, Lucile, and Worden would be suitable, provided they are adapted to such districts.

BAGGING THE FRUIT

Those growing a few grapes for home consumption as well as the more extensive growers producing for a discriminating market can afford to cover the fruit clusters with ordinary paper bags immediately after the blossoms fall. Five-pound paper bags are suitable. The mouth of the bag should be either tied securely around the stem of the cluster or folded over the vine above the cluster in such a manner as to allow the corners to be pinned or fastened with paper clips. This should furnish the clusters ample protection against insects and infection by rot fungi throughout the season.

SANITATION

Since the fungi causing grape diseases live over winter in an inactive state on or within the old foliage, shattered fruit, or the vines, it is obvious that, if any of this infected material can be disposed of in some manner prior to the unfolding of the new leaves and the development of new spring shoots, correspondingly less disease should follow. The annual pruning of the grapevines undoubtedly takes out of the vineyard a large amount of infected material, because the fungi causing black rot, anthracnose, downy mildew, dead arm, and other diseases of less importance live over winter on the vines. Removing and burning canes infected with the dead arm fungus is the most effective method of combating that disease. Measures for controlling anthracnose also include removing and burning infected shoots.

Some cultural practices recommended as an aid in controlling the grape berry moth should also be of help in controlling all diseases that are carried through the winter on old leaves or on shattered diseased fruits. A shallow cover of soil over the old leaves and fruits will prevent the carrying of the spores to the new leaves and shoots by the wind or by the spattering of rain. In small home-garden plantings the leaves and dropped fruits can be gathered and burned during the fall, a practice that will be helpful.

SPRAY MATERIALS

The spray materials mentioned in this bulletin can usually be obtained from local agricultural supply houses. It is important that materials from a reputable manufacturer be used. Brief descriptions of these materials and methods for preparing them are discussed below.

Bordeaux Mixture

Bordeaux mixture is a fungicide that is best prepared at home and used within a few hours. The ingredients are copper sulfate, hydrated lime, and water. As copper sulfate may cause indigestion if taken internally, any unused portion of the mixture should be disposed of or covered so that it will be inaccessible to children and animals. Bordeaux mixture also irritates the eyes and skin.

For spraying grapes, 2 to 8 pounds each of copper sulfate and lime should be used in 100 gallons of water, depending on the time of year and the diseases to be controlled. (See p. 36 for general spray program for grapes.) The copper sulfate should be of the type that will dissolve immediately when added to the spray tank. Less soluble types of copper sulfate must be suspended in burlap bags in wooden vats containing water to dissolve them. The most convenient and available type of lime for the spray is hydrated lime, such as is used in the building trade. Only fresh lime should be used, as old lime is less effective, does not mix well, and tends to clog spray nozzles.

To prepare bordeaux mixture in a spray tank, fill the tank half full of water, start the agitator in the tank, and then add the computed amount of lime based on tank capacity. Allow the agitator to mix the lime thoroughly in the tank, then add the computed amount of copper sulfate. Fill the tank with water. Good agitation is necessary.

To prepare a small quantity of bordeaux mixture for spraying a home vineyard, use 2 level tablespoonfuls of copper sulfate and 6 of hydrated lime to each gallon of water. This is equivalent to a 6 : 6 : 100 mixture. First add the lime to the water and stir until well mixed. Then add the copper sulfate and stir until dissolved. If the addition of an insecticide, or sticker, or both, is desired, add them to the bordeaux mixture last. Mix the spray in the spray receptacle or tank. It will corrode galvanized metal.

Other Spray Materials Containing Copper

Bordeaux mixture and several other spray materials with a higher metallic copper content than the standard copper sulfate may be obtained commercially. If these commercial materials are used to make a bordeaux mixture for grape sprays, smaller quantities are required. Be sure to follow the manufacturer's directions. It is important that hydrated lime be used with all copper sprays in an amount equivalent to the amount, by weight, of the copper spray material used.

Ferbam

Ferbam is the common name for ferric dimethyl dithiocarbamate, a recently developed fungicide. This material is a black, fluffy powder and may be used in place of bordeaux mixture for control of black rot on grapes. It will not control mildew. Two pounds per 100 gallons of spray is the quantity most commonly recommended. Ferbam may be added directly to the water in the spray tank while the agitator is running. It is compatible with commonly used grape insecticides but not with bordeaux mixture. It has less tendency to injure grape foliage than bordeaux mixture.

Lead Arsenate

Lead arsenate is a powdery material that is used as a stomach poison for insects. In the pure form this chemical is white, but when sold for insecticides it is colored pink. **It is a deadly poison and should be stored where children and domestic animals cannot gain access to it. While this substance is being handled, mixed, and applied, full face and skin protection is recommended.** It is ordinarily used at a strength of 3 pounds in 100 gallons of water. For small quantities this is equivalent to approximately 4 rounded teaspoonfuls of lead arsenate per gallon.

DDT

DDT sprays are used generally throughout the eastern grape-growing section for the control of certain grape insects. The most generally used form of DDT is a white wettable powder containing 50 percent of actual DDT. This insecticide mixes readily with water, and it is usually used at the rate of 1½ or 2 pounds per 100 gallons. For small amounts of spray about 1½ or 2 tablespoonfuls of 50-percent DDT powder per gallon of water is required. DDT may be used in combination with fungicides, such as bordeaux mixture or ferbam, or with lead arsenate or parathion.

Caution: DDT is poisonous to human beings and animals. Avoid inhaling the dust or spray and do not allow the sprays to come into prolonged contact with the body or face. Store the DDT in well-marked, tight containers away from children and animals.

Parathion

Commercial parathion is a light-brown powder containing 15 or 25 percent of actual parathion. The parathion wettable powders mix readily with water and are used at the rate of from ¼ to 2 pounds per 100 gallons of spray, depending on the pest to be controlled. Parathion may be used in combination with ferbam, DDT, or lead arsenate, but lime, bordeaux mixture, and alkaline substances reduce its effectiveness.

Caution: Parathion is extremely toxic to human beings. It must be handled with great care and only in the open air or in well-ventilated rooms. Avoid breathing in the wettable powder while opening the bags or putting it into the spray tank. Avoid exposure to spray drift or dust clouds; wear protective clothing if so exposed. Wear a respirator while handling the wettable powder and during the spraying and dusting operations. Never handle parathion spray and dust formulations with the bare hands; if you must handle them with the hands wear natural-rubber gloves. Wash the hands, arms, and face thoroughly with soap and water after handling parathion and before eating or smoking. Bathe and change clothes when you have finished handling it.

In case, through an accident, parathion spray materials strike the face or arms, or the clothing becomes wet with it, change the clothing immediately and wash the exposed parts thoroughly.

If headache, blurred vision, weakness, cramps, nausea, diarrhea, or discomfort in the chest develops while working with parathion, or in or about parathion-sprayed trees, stop work immediately,

bathe and change clothes, and, if the illness persists, call your doctor. Atropine is of value as an antidote in relieving acute symptoms of poisoning from this insecticide. Never use morphine.

Stickers and Spreaders

Certain materials may be added to grape sprays that cause the sprays to spread over the grape surfaces more evenly, or cause the sprays to adhere longer after they have dried. Stickers or spreaders are not always necessary, but may increase coverage and the periods of effectiveness of the early sprays when grape foliage is light, especially with the heavier concentrations of bordeaux mixture or with lead arsenate.

To avoid excessive spray residues at harvest, no stickers should be used in the late sprays (applications 5 and 6 in the general spray program, p. 36).

Various stickers and spreaders may be obtained commercially and should be used as directed by the manufacturer, usually 1 pint to 1 quart for each 100 gallons of spray. The emulsified, or miscible, oil stickers and spreaders are generally preferred. These materials are added to the spray mixtures last. They mix readily with ordinary tank agitation.

GENERAL SPRAY PROGRAM FOR GRAPES

The spray schedule given in table 1 is general in nature and requires modification to adapt it to the needs of each particular locality. More detailed information can be obtained from the local county farm adviser, the State extension service, or the State agricultural experiment station.

It cannot be too strongly emphasized that in the spray program the early sprays are important. Infection of leaves and canes must be prevented if clean fruit is to be produced. Little can be accomplished if spraying is postponed until the fruit begins to rot or insect damage appears.

Difficulties in Controlling Grape Diseases in the South

On account of a long growing season and the frequency of rains in Florida and other South Atlantic and Gulf States, the simple spray schedule found so effective in controlling diseases in the region north of the Ohio River and east to the Atlantic coast has been found inadequate. Therefore, if the reader resides south of Virginia, Tennessee, and Missouri he will do well, before planning his grape-spraying schedule, to consult with his county agricultural agent or write to his State college of agriculture for advice about the timing and number of applications needed.

Although four or five applications of fungicides as recommended may give very satisfactory control of black rot, downy mildew, and anthracnose in northern areas, the number of applications may need to be doubled in the South to get as good results.

TABLE 1.—*General spray program for control of grape diseases and insects*

Application No.	Time of application	Materials (quantities per 100 gallons of water)	Disease or insect	Remarks
1	When new shoots are 7 to 10 inches long.	Ferbam (2 pounds) or bordeaux mixture (6:6:100).	Black rot; dead arm.	In sections where black rot is serious apply an extra spray of 8:8:100 bordeaux mixture or ferbam, 2 pounds, when the young shoots are 1 to 2 inches long. Add DDT to these sprays if overwintering leafhoppers or grape flea beetles are severe.
2	3 to 5 days before bloom period.	DDT, 50-percent wettable powder (1½ to 2 pounds) plus ferbam (2 pounds) or bordeaux mixture (4:4:100).	Black rot Berry moth Rose chafer Japanese beetle	If early mildew is a problem, use bordeaux mixture rather than ferbam. If grapes come into bloom while these sprays are being applied, keep spraying pressure at 350 pounds per square inch or below.
3	Immediately after bloom (petal fall).	Same as for application No. 2, except DDT only 1½ pounds.	Black rot Berry moth Mildew Leafhoppers Rootworm Leafroller Japanese beetle	If red-banded leaf roller is present, add a recommended insecticide to this spray (see p. 24). If mildew is a problem, use bordeaux mixture rather than ferbam.
4	10 days after No. 3 (first cover).	DDT, 50-percent wettable powder (1½ pounds) plus ferbam (2 pounds).	Black rot Berry moth Leafhoppers Rootworm Japanese beetle	The quantity applied per acre should be 250 to 300 gallons.
5	35 to 45 days after grape bloom (second cover).	DDT, 50-percent wettable powder (1½ pounds).	Berry moth Mildew	Timing to apply spray before eggs hatch is important. If mildew is likely to develop, add a 2:2:100 bordeaux mixture to these sprays.
6	10 days after No. 5 (third cover).	Same as for application No. 5.	Berry moth Mealybug Mildew	Must be applied at least 45 days before grape harvest. See p. 26 for mealybug control. If mildew is likely to develop, add a 2:2:100 bordeaux mixture to these sprays.

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